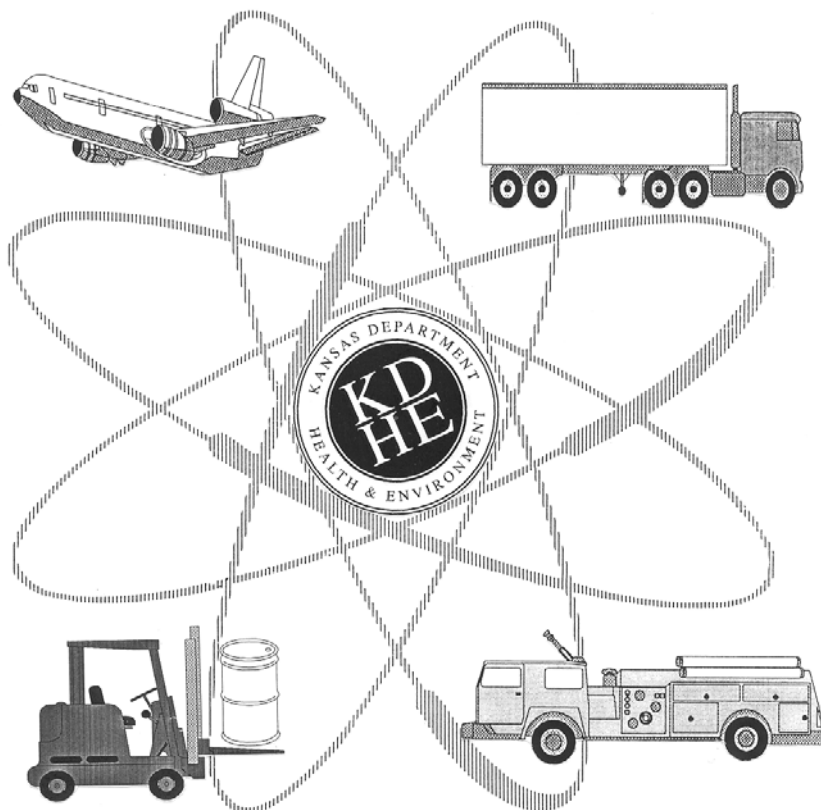


RADIATION EMERGENCY HANDBOOK



KANSAS DEPARTMENT OF HEALTH AND ENVIRONMENT
BUREAU OF AIR AND RADIATION
RADIATION CONTROL PROGRAM
FORBES FIELD, BUILDING 283
TOPEKA, KANSAS 66620

NOTIFICATION IN THE EVENT OF A RADIATION EMERGENCY

IN THE EVENT OF A ACCIDENT OR INCIDENT INVOLVING RADIOACTIVE MATERIALS, THE KANSAS DIVISION OF EMERGENCY MANAGEMENT SERVES AS THE INITIAL POINT OF NOTIFICATION:

24-HOUR TELEPHONE NUMBER -- (785) 296-3176

IN THE EVENT OF AN ACCIDENT OR INCIDENT INVOLVING RADIOACTIVE MATERIALS LICENSED BY THE STATE OF KANSAS, THE KANSAS RADIATION CONTROL PROGRAM MUST BE NOTIFIED IMMEDIATELY:

NORMAL WORK DAYS 8:00 A.M. TO 5:00 P.M. -- (785) 296-1560

OFF-DUTY HOURS, WEEKENDS AND HOLIDAYS -- (785) 296-3176

DURING NORMAL WORKING HOURS, THE CALL WILL BE DIRECTED TO AN APPROPRIATE MEMBER OF THE KANSAS RADIATION CONTROL PROGRAM STAFF. AFTER HOURS, THE DUTY EMERGENCY OFFICER WILL LOCATE THE APPROPRIATE PERSON TO RETURN YOUR CALL. IF YOUR CALL IS ANSWERED BY AN ANSWERING MACHINE, PROVIDE THE APPROPRIATE INFORMATION AND REMAIN AT YOUR TELEPHONE UNTIL YOU ARE CALLED BACK.

IDENTIFY THE CALL AS A **RADIATION EMERGENCY**

AND GIVE THE OPERATOR THE FOLLOWING INFORMATION:

- 1) YOUR NAME
- 2) YOUR LOCATION
- 3) A TELEPHONE NUMBER AT WHICH YOU CAN BE REACHED.
- 4) A DESCRIPTION OF THE EMERGENCY AND THE CURRENT SITUATION (i.e., time, date, injuries, actions taken, etc.).
- 5) ADDITIONAL DETAILS AS REQUESTED.

IN THE EVENT OF A CHEMICAL EMERGENCY
CALL THE FOLLOWING TELEPHONE NUMBER:

24-HOUR TELEPHONE NUMBER -- (785) 296-3176

ADDITIONAL INFORMATION REGARDING CHEMICALS AND HAZARDOUS MATERIALS MAY BE OBTAINED BY CALLING CHEMTREC:

CHEMTREC -- (800) 424-9300

TABLE OF CONTENTS

<u>UNIT NUMBER</u>	<u>PAGE</u>
1.0 Purpose	1
2.0 Objectives	1
3.0 Discussion	1
4.0 Responsibilities	2
5.0 Reporting	3
6.0 Law Enforcement Emergency Actions	3
7.0 Fire Department Emergency Actions	5
8.0 Wrecker-Tow Truck Emergency Actions	6
9.0 Ambulance-Rescue Squad Emergency Actions	7
10.0 Hospital Emergency Actions	8
11.0 Release of Information	10
Appendix A. Guidance for Incidents Involving Radioactive Materials	11
Survey Procedures	15
Personnel Survey Form	16
Vehicle Survey Form	17
Tractor Trailer Truck Survey Form	18
Personnel Decontamination Methods	19
Area and Material Decontamination Methods	20
Appendix B. Labels, Placards, Shipping Papers, and Caution Signs	21
Appendix C. Hospitals with Nuclear Medicine Programs	25
Appendix D. Table of Nuclides	26
Appendix E. Conversion Charts for SI Units	29
<u>FIGURES</u>	
Figure 1. Survey Procedure	15
Figure 2. Sample Tag For Bagged Clothing and Personal Items	15
Figure 3. Radioactive Labels	21
Figure 4. Typical Radioactive Warning Placard	22
Figure 5. Sample Shipping Papers	23
Figure 6. Typical Signs or Labels Indicating the Presence of Radiation or Radioactive Materials	24

1.0 Purpose

To provide guidance for government agencies, radioactive material users and licensees, and individuals in the State of Kansas whose responsibilities are such that they may be called upon to assist in some manner in the event of a radiation emergency. It is not intended to provide rigid procedures in anticipation of all situations that may be encountered, nor to replace the existing emergency plans of an agency or licensee.

This publication is not intended for use in responding to an accident or incident at a nuclear power plant.

2.0 Objectives

- 2.1 To identify the types and conditions of radiation emergencies and the appropriate response and communications required.
- 2.2 To provide a guidance matrix for the Kansas Department of Health and Environment (KDHE) in responding to radiation emergencies in Kansas.
- 2.3 To identify the appropriate agencies and individuals, within and outside of Kansas, that should be made aware of and/or respond to radiation emergencies.
- 2.4 To outline the minimum responsibilities of Kansas agencies, radioactive material licensees, and individuals involved with radiation emergencies.

3.0 Discussion

Radioactive materials are used in a wide variety of applications in Kansas. It would be futile to list all of the emergency possibilities and corresponding action procedures. However, it is reasonable to expect that most radiation emergencies would be associated with transportation, fire, natural disaster, utilization, or lost material accidents/incidents.

Rigidly planned procedures alone provide little success in dealing with actual emergencies and training exercises. A detailed procedure list, prepared in advance, cannot anticipate all of the conditions that may be encountered in an actual emergency situation. A simple and logical set of guidelines, supported by proven radiological health principles and made flexible for different scenarios, will prove to be a more useful tool. The following general emergency action guidelines are such a tool:

Emergency Action Guidelines

- 3.1 STAY CALM. THINK. SEEK ASSISTANCE.
- 3.2 Perform life saving rescue and emergency first aid.
- 3.3 Notify KDHE's Radiation Control Program:

Normal Hours 8:00 a.m. - 5:00 p.m. weekdays -- **(785) 296-1560**

Other Hours -- **(785) 296-3176** *(You will probably reach an answering machine. Provide the appropriate information including a telephone number, and wait near your telephone for a response.)*

- 3.4 Keep all non-essential persons away from the accident/incident area.
- 3.5 Stay upwind from fires.

- 3.6 Obtain names, addresses, and phone numbers of all persons involved.
- 3.7 Detain potentially contaminated non-injured persons involved with the incident until a representative of KDHE's Radiation Control Program arrives at the scene or until it can be determined by a qualified radiation monitor that they are not contaminated.
- 3.8 Do not attempt to perform radiation surveys unless properly trained.

Radiation emergency training materials and assistance are available from KDHE's Radiation Control Program upon request.

4.0 Responsibilities

- 4.1 Agencies or individuals who are licensed to possess, use and transport radioactive materials have a responsibility to conduct such activities in compliance with all applicable rules and regulations. This must be done in a manner which minimizes the opportunity for a radiation accident.
- 4.2 The Kansas Department of Health and Environment, Radiation Control Program is designated by Chapter 290, Article 16, of the Kansas Revised Statutes, as the Agency responsible for protecting the health and safety of its citizens from the hazards of radiation sources. Should a radiation emergency occur, the Department has the authority to issue orders for the protection of the public, as may be deemed appropriate. This will be carried out through KDHE's Radiation Control Program. Once the Radiation Control Program staff has been notified that a radiation emergency exists, it will be their responsibility to determine the radiation control actions necessary. Depending on the extent of an emergency, a radiation emergency response team may be dispatched to the scene. Response time of the team will vary depending on the location in Kansas of the emergency. In some instances, it may be possible for an incident/accident involving radiation to be handled over the phone, without the need for Radiation Control Program personnel at the scene.

The following outlines the most significant responsibilities of the Radiation Control Program:

- 4.2.1 Evaluate the radiation aspects of the emergency and determine what action is necessary.
- 4.2.2 Provide technical radiation assistance.
- 4.2.3 Conduct radiation and contamination surveys.
- 4.2.4 Perform dose assessments.
- 4.2.5 Collect and analyze radiation health and safety data.
- 4.2.6 Provide technical information to appropriate authorities.
- 4.2.7 Make protective action recommendations and issue appropriate orders where necessary.

The Radiological Emergency Assistance Center/Training Site (REAC/TS) in Oak Ridge, Tennessee has published documents and a corresponding video for the Federal Emergency Management Agency (FEMA) entitled Pre-Hospital Management of Radiation Accidents (OARU-223, 1984), and Hospital Emergency Department Management of Radiation Accidents (SM 80, 1984). The Radiation Control Program has a copy of this and other (VHS) videos available for loan and will provide one copy of each document upon request. The Radiation Control Program may provide training seminars upon request.

- 4.3 The Adjutant General's Department, Division of Emergency Management (KDEM) has overall responsibility for coordinating state and local government emergency response operations, including response to radiation accidents or incidents. Its major radiological responsibilities include developing state and local plans and resources to cope with radiation accidents and incidents. All accidents or incidents recognized by a local Emergency Management Organization must be immediately reported to the State of Kansas, Division of Emergency Management (KDEM), Technological Hazards Section (TECH-HAZ):

(785) 296-3176 (24-Hour Telephone Number)

If Emergency Management personnel are made aware of a radiation accident or incident of any type, before the Department of Health and Environment (KDHE), they will immediately notify the Radiation Control Program of such.

5.0 Reporting

All radiation emergencies must be reported to the Kansas Department of Health and Environment, Radiation Control Program in Topeka, Kansas. The off-duty hours, weekend and holiday telephone number is that of the KDEM duty emergency officer. When contacted regarding a radiation emergency, the KDEM duty emergency officer will report the emergency to an appropriate Radiation Control Program staff member at home.

6.0 Law Enforcement Emergency Action

Law enforcement personnel will have an important role in certain radiation emergencies. Therefore, it is important for the State Highway Patrol, municipal police, sheriffs, and local law enforcement officials to be made aware of necessary emergency procedures.

- 6.1 The following is a description of some of the various radiation emergencies with which law enforcement officers may become involved:
 - 6.1.1 TRANSPORTATION accidents involving private or commercial carriers and the movement of radioactive materials.
 - 6.1.2 EXPLOSION and/or FIRE within or near buildings or vehicles containing radioactive materials.
 - 6.1.3 STOLEN or LOST radioactive materials.
 - 6.1.4 INJURIES resulting from the exposure and/or contamination of individuals by radioactive materials.

- 6.1.5 TERRORISM or THREATS (implied or actual) regarding the unlawful use of radioactive materials, or radiation producing devices or ordnance.
- 6.2 The Radiation Control Program must be notified immediately of any accidents involving radioactive materials or when a potential radiation hazard exists.
- 6.3 The following are guidelines to be followed by law enforcement personnel in the event that they respond to a scene or an accident involving radioactive material:
- 6.3.1 Perform rescue and first aid.
 - 6.3.2 If a vehicle is involved, look for placards and/or labels to see if radioactive materials are involved and if so find the shipping papers in the driver's compartment of the truck as soon as practical.
 - 6.3.3 Keep unessential personnel as far as practical from the accident area (150 foot radius exclusionary zone) and upwind from any smoke.
 - 6.3.4 Except for rescue efforts, restrict access to the accident area and prevent unnecessary handling and movement of accident debris.
 - 6.3.5 Inform ambulance, rescue squad and/or fire fighters, that the accident involves radioactive materials. Regardless of contamination, severely injured individuals can be transported to a medical treatment facility.
 - 6.3.6 Detour pedestrian and vehicular traffic. If a right-of-way must be cleared before a Radiation Control Program representative arrives, move vehicles and debris the shortest distance necessary to open a pathway.
 - 6.3.7 If a fire accompanies the accident, stay upwind from the smoke, fumes, and dust as much as possible.
 - 6.3.8 Do not permit any material suspected of being contaminated to be removed until it has been properly surveyed.
 - 6.3.9 Obtain names and addresses of persons involved. Individuals who are not injured but are suspected of being contaminated should be surveyed by a qualified individual before leaving the accident area.
 - 6.3.10 Questions regarding the presence of radiation at the accident should be forwarded to a member of the Radiation Control Program.
 - 6.3.11 Do not permit smoking, eating, or drinking within the exclusionary zone or by persons who may be contaminated.
 - 6.3.12 Do not perform radiation surveys unless proper equipment and trained personnel are available.

7.0 Fire Department Emergency Action

In many cases, fire may alter the chemical or physical form of radioactive material and its packaging, but will not alter its radioactivity. The dispersal of radioactive material may be significantly enhanced by a fire and the environmental factors associated with it. A fire that involved certain radioactive material and has been extinguished can still be very dangerous.

Most radioactive materials are not pyrophoric, but a fire can destroy the integrity of protective packaging and shielding. A few radioactive materials such as metallic uranium, plutonium, thorium, and magnesium are pyrophoric. Some radioactive materials, such as sodium, react violently with water. As with any other type of fire, the smoke will contain fumes and particulates. Respiratory protection should be utilized. Protective overgarments will provide some shielding from radiation exposure and protection from contamination.

7.1 Preplanning.

- 7.1.1 Upon request, the Radiation Control Program will furnish, to any fire department in the state, a list of licensees using radioactive materials within a particular fire department's jurisdiction. This list will also identify each facility's Radiation Safety Officer (RSO).
 - 7.1.2 The Fire Marshall should contact the RSO at each facility and evaluate potential problems which may be encountered in the event of a fire at their facility.
 - 7.1.3 Plans should be developed between the fire department and the licensee as to how to handle potential problems in the event of a fire.
- 7.2 In the event of a fire, the KDHE Radiation Control Program and the facility's RSO should be notified. In commercial motor carrier accidents, the manifest in the driver's compartment will identify the name of the shipper. This individual should be contacted as well.
- 7.3 The following are guidelines to be followed by fire department personnel in the event that they respond to a fire scene or an accident involving radioactive material:
- 7.3.1 Rescue people and perform first aid as needed. Possible personnel contamination should not preclude lifesaving measures.
 - 7.3.2 Look for placards and/or labels to see if radioactive materials are involved and if so find the shipping papers in the driver's compartment of the truck as soon as practical.
 - 7.3.3 Provide protective breathing apparatus to personnel as required. Smoke, fumes, or dust from radioactive materials may be inhalation hazards.
 - 7.3.4 Extinguish fire as rapidly as possible. An effort should be made to isolate the fire from the radioactive material or other hazardous material first.
 - 7.3.5 Work upwind from the fire. Keep out of the smoke.
 - 7.3.6 Keep personnel exposure to radiation **As Low As Reasonably Achievable (ALARA)**.

- 7.3.7 Keep the public as far from the scene as practical (150 foot radius exclusionary zone). Keep them out of the smoke.
- 7.3.8 Keep runoff from spreading through the use of earthen dams or absorbent materials.
- 7.3.9 Use caution when removing clothing so as not to spread potential contamination. If practical to do so, wash exposed skin (hands and face) thoroughly at the scene.
- 7.3.10 Equipment, clothing, and uninjured personnel must be surveyed for radioactive contamination before leaving the scene. Decontamination may be necessary. If decontamination is not practical, clothing may be placed in plastic trash bags until they can be properly surveyed. Such bags should be tagged with "Caution - Radioactive Materials".
- 7.3.11 Do not permit smoking, eating, or drinking within the exclusionary zone or by persons who may be contaminated.

8.0 Wrecker-Tow Truck Emergency Actions

Drivers and assistants on wreckers or tow trucks may have an important role in certain radiation emergencies. Therefore, it is important for these individuals to be made aware of necessary emergency procedures.

- 8.1 The following is a description of some of the various radiation emergencies with which wrecker or tow truck drivers and assistants may become involved:
 - 8.1.1 Transportation accidents involving private or commercial carriers and the movement of radioactive materials.
 - 8.1.2 Explosion and/or fire within or near vehicles containing radioactive materials.
 - 8.1.3 Movement of heavy materials or shielding away from or next to radioactive materials or sources to permit extraction of personnel or recovery of sources.
- 8.2 The Radiation Control Program must be notified immediately of any accidents involving radioactive materials or when a potential radiation hazard exists. It should not be assumed that other agencies or individuals have already notified Program staff.
- 8.3 The following are guidelines to be followed by wrecker or tow truck drivers or assistants in the event that they are called to an accident scene involving radioactive materials:
 - 8.3.1 Attempt to position your vehicle upwind from any smoke and outside any exclusionary zones (150 feet radius typical) until required to move vehicles, heavy materials, or assist in extraction of injured. Try to avoid smoke and spilled materials.

- 8.3.2 Determine who is acting as incident commander. May be fire, police, or emergency management personnel depending upon the situation and timing.
- 8.3.3 Obtain a briefing on the radioactive or other hazardous materials present at the scene and look for placards and/or labels to see if radioactive materials are involved. If there is no incident commander, or if asked to do so, assist in locating the shipping papers in the driver's compartment of the vehicle or in the driver's possession.
- 8.3.4 Do not remove or tow away any vehicles or materials suspected of being contaminated until they have been properly surveyed. Radiation Control Program personnel will coordinate movement of contaminated materials or vehicles.
- 8.3.5 Do not unnecessarily disturb debris at an accident scene where there is a potential for radioactive contamination until such actions are approved by the incident commander.
- 8.3.6 Questions regarding the presence of radiation at the accident should be forwarded to a member of the Radiation Control Program.
- 8.3.7 Do not smoke, chew, eat, or drink within the exclusionary zone or if you may be contaminated. This minimizes the potential for ingestion of radioactive contamination.
- 8.3.8 You and your wrecker or tow-truck should be surveyed by a Radiation Control Program member or other qualified monitor for radioactive contamination before leaving the scene.

9.0 Ambulance-Rescue Squad Emergency Actions

In some accidents, the members of an Ambulance-Rescue Squad could be the first individuals to arrive at the scene. The following is a list of guidelines to be followed when an accident involves radioactive material:

- 9.1 Approach from upwind.
- 9.2 Look for placards and labels. The ambulance and personnel should avoid smoke and spilled materials.
- 9.3 Rescue any victims and give lifesaving emergency assistance if needed.
- 9.4 Remove any clothing which may be contaminated. Bag the clothing and label it with "Caution - Radioactive Materials", until it can be evaluated by Radiation Control Personnel.
- 9.5 Cover stretcher, including pillow, with open blanket; wrap victim in blanket to limit the spread of radioactive contamination.
- 9.6 Provide pertinent information, including the potential of radioactive contamination, to the receiving hospital by radio or telephone.
- 9.7 Save all material suspected of being radioactively contaminated in plastic containers or bags labeled "Caution - Radioactive Materials".

- 9.8 Ensure that Ambulance-Rescue Squad personnel and equipment suspected of being radioactively contaminated are surveyed by a Radiation Control Program member or other qualified radiation monitor after completing the mission.
- 9.9 Notify the Radiation Control Program and inform them where the patient(s) is being taken.
- 9.10 After work, carefully remove protective clothing and perform a survey of the clothing. If the clothing is contaminated, it may be stored in plastic trash bags labeled "Caution - Radioactive Materials" until it can be evaluated by Radiation Control Personnel. Thoroughly wash hands and face afterwards.

10.0 Hospital Emergency Actions

The ability of a particular hospital to treat contaminated patients and to manage personnel and resources varies considerably. Larger hospitals may have an active nuclear medical department with a staff which is familiar with radiation matters, while a small medical treatment facility may not have such a benefit. Planning and preparedness training/drills are recommended. Appendix C lists some of the hospitals in Kansas which have active nuclear medicine departments.

Two points must be remembered when treating patients who had been involved in a radiation accident:

1. Exposed patients **are not** radioactive.
2. Contaminated patients may have **removable** radioactivity which may cause additional exposure.

The following is a list of general guidelines for hospital personnel involved in treating a patient exposed and/or contaminated with radiation:

10.1 Emergency Room Personnel

- 10.1.1 Upon notification that a radiation accident patient is being transported to the facility, notify responsible staff physicians, hospital administrators, and medical/health physicist or RSO (if available) and prepare to receive the accident victim(s).
- 10.1.2 Prevent the spread of contamination by covering (with paper or plastic) areas that may receive heavy traffic by contaminated individuals. Cover equipment and HVAC vents with paper or plastic wrap.
- 10.1.3 Ensure that enough waste receptacles are available to store contaminated waste.
- 10.1.4 Materials suspected of having radioactive contamination should be bagged, labeled, and stored for survey by a Radiation Control Program representative.
- 10.1.5 Protective clothing, such as surgical clothing, should be worn by attendant personnel. If available, dosimetry badges should be acquired from the Radiology Department and worn at all times by those individuals attending the patient.

- 10.1.6 After work, carefully remove protective clothing and perform a survey of the clothing. If the clothing is contaminated, it may be stored in plastic trash bags labeled "Caution - Radioactive Materials" until it can be evaluated by Radiation Control Personnel. Thoroughly wash hands and face afterwards.
- 10.1.7 A thorough radiation contamination survey should be performed on facilities, equipment, and personnel involved in handling and treating the patient.

10.2 Physicians

- 10.2.1 **Do not let the risk of contamination preclude attempts to treat life threatening injuries first.**
- 10.2.2 If possible, a radiation survey meter should be used to identify significant areas of contamination. Isolate and/or decontaminate those areas as soon as possible. Universal body fluid precautions should be used.
- 10.2.3 If potential external contamination is involved, place the patient's clothing and bedding in plastic bags which are labeled "Caution - Radioactive Materials", and store for radiation survey.
- 10.2.4 Collect nasal swabs, urine and blood samples as soon as possible. Retain for later evaluation as arranged for by a member of the Radiation Control Program.
- 10.2.5 Decontamination should start, if medical status permits, with cleansing and scrubbing the area of highest contamination. Initial cleaning should be done with warm water and soap. Waste water can be disposed of via the sewer system.
- 10.2.6 When external contamination is complicated by a wound, care must be taken not to cross-contaminate surrounding surfaces from the wound and vice versa.
- 10.2.7 After work, carefully remove protective clothing and perform a survey of the clothing. If the clothing is contaminated, it may be stored in plastic trash bags labeled "Caution - Radioactive Materials" until it can be evaluated by Radiation Control Personnel. Thoroughly wash hands and face afterwards.

10.3 Hospital Administrator

- 10.3.1 Ensure that plans and procedures have been established to handle radiation emergency situations.
- 10.3.2 Ensure that personnel are familiar with precautions and proper treatment of a patient involved in a radiation accident.
- 10.3.3 Notify the Radiation Control Program whenever a radiation accident patient arrives at the facility.

11.0 Release of Information

In the event of a radiation accident, The Adjutant General's Department/Kansas Division of Emergency Management (KDEM) is responsible for all information released to the general public and media (785-274-1192).

In the same event, media release information from the Radiation Control Program will be sent to KDEM through the KDHE Office of Public Information Services (785-296-5795).

APPENDIX A

Guidance for Incidents/Accidents Involving Radioactive Materials

The following guidance is intended for radioactive materials licensees and users, and other individuals involved with the use of radioactive materials:

1. GENERAL GUIDANCE:

1.1 Notification

- 1.1.1 Notify any persons in the room/area at once. Notify the Radiation Safety Officer (RSO) as soon as possible. The RSO will be responsible for notifying the KDHE Radiation Control Program. In the absence of an RSO, notify the KDHE Radiation Control Program directly.

1.2 Securing the Area

- 1.2.1 Secure the room/area, post warnings as appropriate, and permit access only to the minimum number of qualified persons necessary to deal with the incident.

1.3 Protective Equipment/Actions

- 1.3.1 Don protective clothing (including gloves), dosimetry, and/or respiratory equipment if necessary.
- 1.3.2 Apply the principles of time, distance, and shielding to minimize exposure (i.e., limit the time spent in a radiation area; keep as much distance as possible between the radiation area and any individuals; and, shield individuals with any available material, including protective clothing.).

1.4 Surveys *NOTE: Radiation surveys should be performed only by individuals properly trained for such.*

- 1.4.1 All persons who may have been contaminated must be monitored. Those individuals who have been contaminated must remove and bag all contaminated clothing. Any equipment which may have been contaminated must also be placed in plastic bags. The bagged clothing and equipment should be labeled "Caution-Radioactive Materials" (see page 15 for an example of a tag) and stored until it can be evaluated by Radiation Control Personnel. Any contaminated body areas should be washed immediately using mild soap and warm water.
- 1.4.2 In general, any individual or surface on which the survey result is 100 cpm or more above the measured background level should be considered contaminated until the situation can be evaluated by Radiation Control Program staff.

- 1.4.3 The speed of the probe over any surface during a radiation survey should not exceed one to two inches per second, and the distance from the probe to the surface being surveyed should be approximately one (1) inch.
- 1.4.4 Monitor all persons and equipment who were involved in resolving the incident (see page 15 for an illustration of the monitoring procedure).

1.5 Decontamination

NOTE: See pages 16, 17, and 18 for personnel, vehicle, and tractor trailer truck survey forms.

- 1.5.1 The RSO will direct decontamination of area and personnel. In the absence of an RSO, a member of the KDHE Radiation Control Program will provide assistance as soon as practical. The tables on page 19 and 20 describe some decontamination methods which may be applied. In general, decontamination should not be attempted unless it is performed by or under the direction of someone who is knowledgeable about such.

1.6 Final Survey

- 1.6.1 Perform a complete survey (including air if necessary) of the room/area and permit no person to resume work in the area without the approval of the RSO or KDHE Radiation Control Program.

1.7 Report

- 1.7.1 Prepare a complete history of the incident and subsequent remedial or protective measures. Forward a copy of this report to the KDHE Radiation Control Program.

2. SPECIFIC GUIDANCE:

2.1 Minor spills involving no immediate radiation hazard to personnel:

- 2.1.1 Confine the spill and prevent it from reaching additional areas. Wear disposable latex gloves during this procedure.
- 2.1.2 Liquid spills: Place absorbent paper on spill.
- 2.1.3 Dry spills: Place dampened paper material on the spill and prevent the spread of the contamination. In general, water may be used except if a chemical reaction with the water would occur. In this case, consider using blotter with mineral oil.
- 2.1.4 After preparing a plan of action, decontaminate. This can be done by cleaning from the outside of the spill and moving toward the center.

2.2 Spills involving radiation hazards to personnel:

- 2.2.1 If it is a liquid spill, turn the container upright by use of a remote handling device (tongs, stick, lever, etc.). When the handling device is no longer needed, ensure that it does not become a source of contamination. Wear disposable latex gloves during this procedure.
- 2.2.2 Decontaminate the area.

2.3 Incidents involving radioactive dusts, mists, fumes, organic vapors, and gases:

- 2.3.1 Report all known or suspected inhalations of radioactive materials to the RSO or KDHE Radiation Control Program as soon as possible.
- 2.3.2 If a potential airborne hazard exists, shut off all ventilation and fans, and close or cover air ducts.
- 2.3.3 Determine the cause of contamination and rectify the condition.
- 2.3.4 Don respirators and initiate air sampling prior to and during cleanup.

2.4 Incidents involving sealed sources:

*Note: Sealed sources will generally present only an **external** radiation exposure hazard unless the encapsulation has been broken.*

- 2.4.1 Isolate the area and identify a radial boundary of 2 mR/hr. If a survey meter is not available, a 150 foot default radial boundary may be used.
- 2.4.2 If necessary, perform an air or swipe survey to help determine if the encapsulation has been broken. Wear disposable latex gloves during this procedure.
- 2.4.3 Keep exposure As Low As Reasonably Achievable (ALARA) utilizing the principles of time, distance, and shielding.
- 2.4.4 Evaluate the hazard and requirements for safe re-entry and retrieval of sealed source. Actual mitigation of the hazard should be attempted only by individuals who are properly trained and experienced in such activities.

2.5 Injuries to personnel contaminated or exposed to radiation:

- 2.5.1 Perform all lifesaving actions necessary.
- 2.5.2 Wash minor wounds under warm running water immediately.

- 2.5.3 Report all personnel data (wounds, overexposures, ingestion, inhalation) to RSO or KDHE Radiation Control Program as soon as possible.
- 2.5.4 Contact a physician qualified to treat radiation injuries.
- 2.5.5 Permit no person involved in a radiation injury to return to work without the approval of the attendant physician and the RSO or the KDHE Radiation Control Program.

2.6 Fires or other major emergencies:

- 2.6.1 If radiation hazard is not immediately present, attempt to put out the fire by approved means and prevent the fire from involving the radioactive material.
- 2.6.2 Perform fire fighting or emergency activities according to the directions of the Incident Commander. If possible, avoid the tracking of contamination or passing of contaminated equipment into clean areas by emergency workers.
- 2.6.3 Following the emergency, monitor the area and determine the protective devices necessary for safe decontamination.
- 2.6.4 After preparing a plan of action, decontaminate.

SURVEY PROCEDURE FOR PERSONAL CONTAMINATION

Begin with the probe on one side of the neck at the collar and proceed up the side of the head, over the top of the head and down the other side, the shoulder, arm, hand, underarm, armpit, side of body, side of leg and bottom of shoe. Then monitor the inside of the leg from the shoe to the groin and continue the procedure on the other side of the body. This procedure should be followed by monitoring the front and back of the upper trunk as well as the front and back of each leg from the waist to the cuff (See Figure 1.). Probe movement should not exceed 1-2 inches per second. The distance from the probe to the surface being surveyed should be approximately one (1) inch.

FIGURE 1. SURVEY PROCEDURE

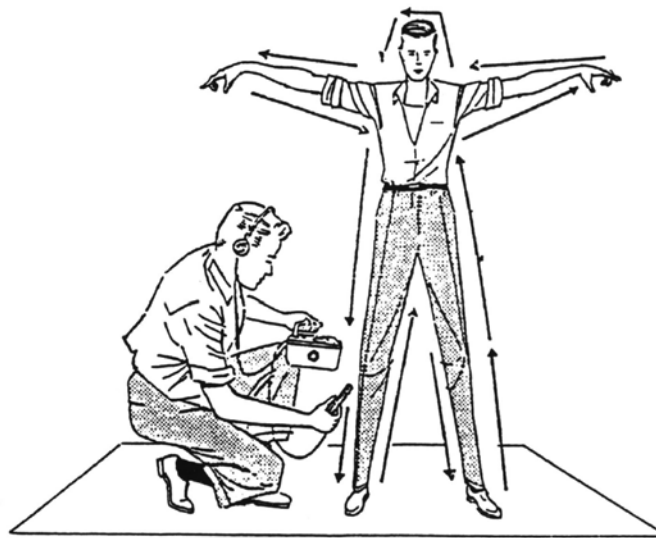


FIGURE 2. SAMPLE TAG FOR BAGGED CLOTHING AND PERSONAL ITEMS

CAUTION - RADIOACTIVE MATERIALS	
BAG NUMBER _____	SURVEY LOCATION _____
NAME _____	
ADDRESS _____	
TELEPHONE _____ SOC. SEC. # _____	
ARTICLES/ AVG CPM	_____
_____	_____
_____	_____
_____	_____
SURVEYED BY _____	DATE _____ TIME _____

PERSONNEL SURVEY FORM

Name: _____

Address: _____

Telephone: _____

Injuries/Symptoms of Illness: _____ None Apparent: _____

Background cpm: _____ Contaminated Clothing: Yes _____ No _____
(Exceeding 100 cpm above background)

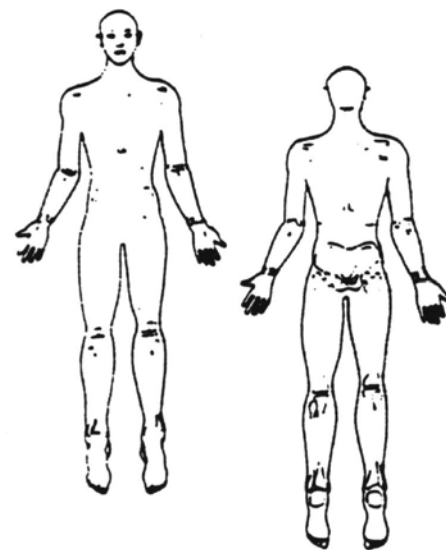
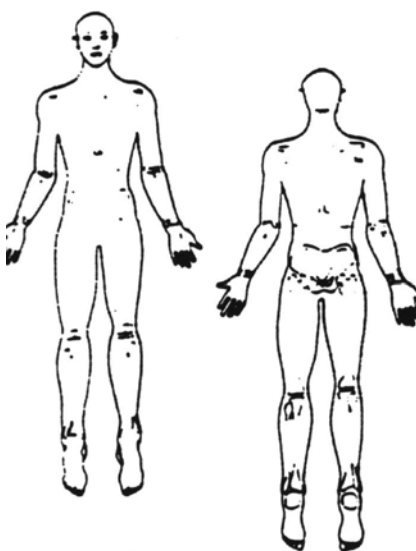
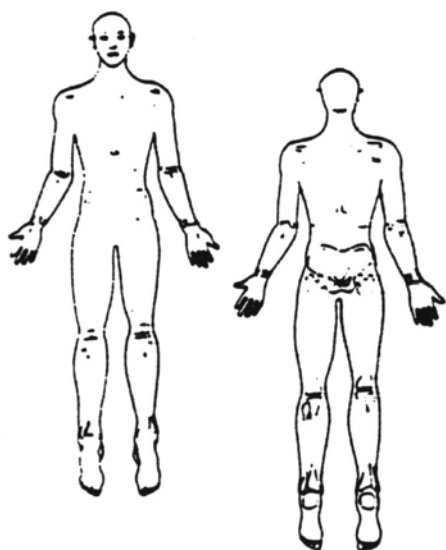
Clothing Bagged and Tagged (Y/N): _____ Tag #: _____

Other: _____

Initial Survey
(With clothing on)

Survey after 1st
decontamination

Survey after 2nd
decontamination



Contamination on body Y or N
(over 100 cpm above backgnd)
Circle the areas of
contamination on the drawing
and write in how many cpm.

Released/Sent to Decon.

Monitor: _____

Time: _____

Date: _____

Instrument
Model: _____

Serial No.: _____

Contamination on body Y or N
(over 100 cpm above backgnd)
Circle the areas of
contamination on the drawing
and write in how many cpm.

Released/Sent to Decon.

Monitor: _____

Time: _____

Date: _____

Instrument
Model: _____

Serial No.: _____

Contamination on body Y or N
(over 100 cpm above backgnd)
Circle the areas of
contamination on the drawing
and write in how many cpm.

Released/Sent to Hospital
Hospital Name: _____

Monitor: _____

Time: _____

Date: _____

Instrument
Model: _____
Serial No.: _____

VEHICLE SURVEY FORM

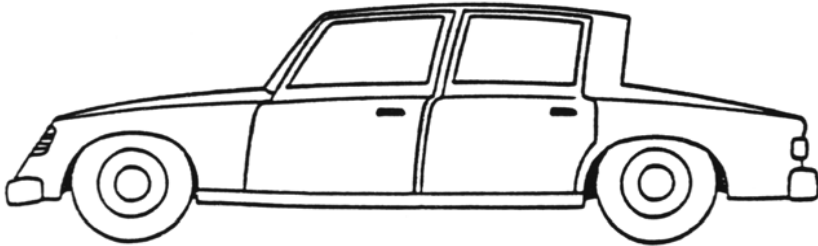
EXTERIOR

Owner's name: _____
Driver's name: _____ Employer: _____
Vehicle Make: _____ Model: _____ Year: _____ Lic. No. _____
Vehicle Contamination Level: (Indicate Contamination Levels
on drawing)

Driver's Side

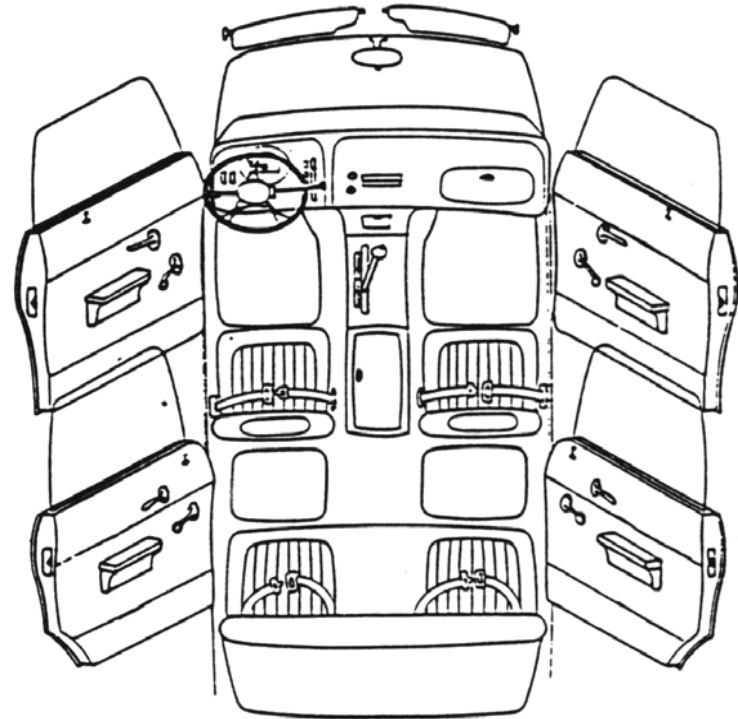
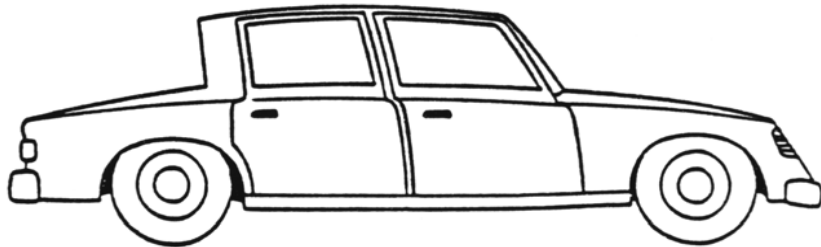
Passenger's Side

When vehicle has been decontaminated, draw a single line
through the contamination level and indicate clean level
below it.



Surveyed by: _____ Date: _____

Instrument Serial No.: _____



When Vehicle has been decontaminated, draw a single line
through the contamination level and indicate clean level
below it.

Surveyed by: _____ Date: _____

Instrument Serial No.: _____

INTERIOR

Vehicle Contamination Level: (Indicate Contamination Levels
on drawing)

TRACTOR TRAILER TRUCK SURVEY FORM

Driver's Name:

FIRST	MIDDLE	LAST
-------	--------	------

**Carrier's Name
(Company):**_____

Address:

STREET	CITY	STATE	ZIPCODE	PHONE
--------	------	-------	---------	-------

Shipper's Name:

Address:

STREET	CITY	STATE	ZIPCODE	PHONE
--------	------	-------	---------	-------

Truck License Number:

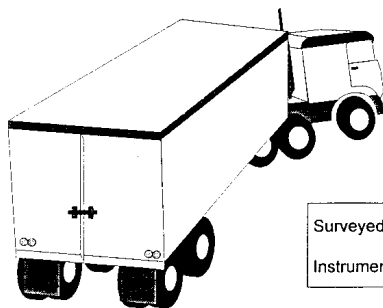
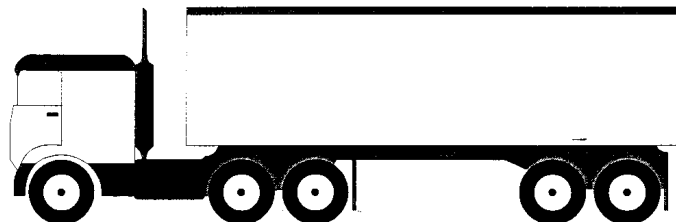
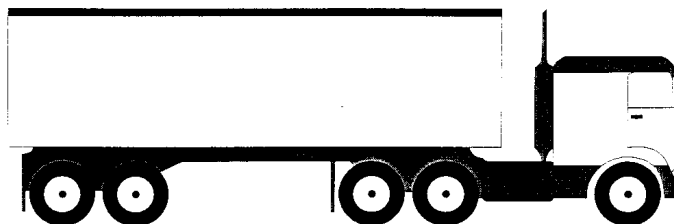
Cargo:

Point of Origin:_____

Destination:

CITY STATE CITY STATE

Truck Contamination Level:
Indicate contamination levels and locations on the drawings below.



When the truck has been decontaminated, draw a single line through the contaminated level and indicate the **clean** level below it.

Surveyed by: _____ Date: ____/____/____

Instrument Model #: _____ Serial #: _____

KDHE/OGCR-DTP 95.08-23

PERSONNEL DECONTAMINATION METHODS

Surface	Method	Technique
Skin	Warm Water Alone or Soap & Water	Protect non-contaminated adjacent skin areas by covering with waterproof drapes. Wash area thoroughly for 2-3 minutes and rinse. Blot area dry with a disposable towel. Survey and record the results. If contamination persists, repeat once or twice.
Skin & Hands	Lava Soap	Use light pressure with heavy lather. Wash for several minutes. Rinse. Repeat as required. Use care not to scratch or erode the skin.
Skin & Hands	Mechanic's Waterless Hand Cleaning Cream	Wash thoroughly. Rinse.
Skin & Hands	Tide, Cornmeal, & Warm Water	For persistent contamination on the palms, elbows, knees or calloused skin, wash with a paste made of Tide, Corn Meal, and tepid water, then rinse. CAUTION: This decontamination mixture is very abrasive and extreme care should be exercised not to abrade the skin excessively.
Skin & Hands	Clorox	For persistent contamination on small localized areas, try gentle application of Clorox using a cotton swab applicator or gauze pad, then rinse thoroughly with water.
Hair	Shampoo & Warm Water	Wash hair with mild shampoo. Rinse thoroughly. Repeat as necessary. For persistent, localized hair contamination, remove hair by clipping. CAUTION: Shaving may cause abrasion of skin and should be used only when all other techniques are ineffective.
Eyes	Warm Water	Roll back the eyelid. Flush with large amounts of water. Use isotonic irrigants if available - apply to eye and flush with large amounts of water.
Nose, mouth, ears	Warm Water	Gently clean orifices by using wetted swabs or flushing. Contaminated individuals should avoid swallowing rinses from nose or mouth.
Wounds	Sterile Saline	Protect non-contaminated adjacent skin areas by covering with waterproof drapes. Irrigate wound with sterile saline, or dab with gauze pads soaked in sterile saline.
Leather goods shoe soles, metal, plastics, etc.	Tape	Use dabbing technique with sticky side of tape.

AREA AND MATERIAL DECONTAMINATION METHODS

Surface	Method	Technique
All surfaces	Water	<u>For small surfaces:</u> Blot up liquid and land-wipe with water and appropriate commercial detergent. Extremely effective if done immediately after spill and on nonporous surfaces. <u>For large surfaces:</u> Hose with high-pressure water at an optimum distance of 15 to 20 feet. Spray vertical surfaces at an angle of incidence of 30 to 40 degrees; work upwind to avoid spray. Oiled surfaces cannot be decontaminated.
Dry Surfaces	Vacuum cleaning	Use conventional vacuum technique with efficient filter. Good on dry, porous surfaces. All dust must be filtered out of exhaust. Machine is contaminated.
Nonporous	Steam	<u>Especially painted or oiled surfaces:</u> Work from top to bottom and from upwind. Clean surface at a rate of 4 square feet per minute. The cleaning efficiency of steam will be greatly increased by using detergents.
Nonporous	Detergents	<u>Metal, painted, glass, plastic, etc.:</u> Rub surface 1 minute with a rag moistened with detergent solution then wipe with dry rag; use clean surface of the rag for each application. Use a power rotary brush with pressure feed for more efficient cleaning.
Nonporous	Organic solvents	<u>Greasy or waxed surfaces, paint or plastic finishes, etc.:</u> Immerse entire unit in solvent or apply by wiping procedure (see Detergents).
Metal	Inorganic acids	<u>Especially with porous deposits; i.e., rust or calcareous growth);circulatory pipe systems:</u> Use dip-bath procedure for movable items. Acid should be kept at a concentration of 1 to 2 normal (9 to 18% hydrochloric, 3 to 6% sulfuric acid). Leave on weathered surfaces for 1 hour. Flush surface with water, scrub with a water-detergent solution, and rinse. Leave in pipe circulatory system 2 to 4 hours; flush with plain water, a water-detergent solution, then again with plain water.
Nonporous	Abrasion	Use conventional procedures, such as sanding, filing, and chipping; keep surface damp to avoid dust hazard.
Nonporous	Sand-blasting	Keep sand wet to lessen contamination spread. Collect used abrasive or flush away with water. Practical for large surface areas.

APPENDIX B

Labels, Placards, Shipping Papers, and Caution Signs

State and Federal regulations require that radioactive packages, motor transport vehicle, radioactive sources, and areas with radioactive materials be properly identified.

1. **Labels:** Depending on the quantity and type involved, most packages of radioactive material, unless exempt, must be labeled on two opposite sides, with a Radioactive-White I, Radioactive-Yellow II or Radioactive-Yellow III label. The information on these labels shall indicate isotope, activity (In Becquerel units, with optional Curie units following in brackets), and Transport Index (T.I.) (mSv/hr x 100, equivalent to mrem/hr at one meter). The information contained in Title 49, Part 172.403 of the Code of Federal Regulations identify the maximum radiation level for each type of labeled package. Standard size of the labels is approximately 4 x 4 inches.

FIGURE 3. Radioactive Labels



RADIOACTIVE WHITE I LABEL

*0.5 mrem/hr maximum on surface of package



RADIOACTIVE YELLOW II LABEL

*50 mrem/hr maximum on surface of package

*Maximum T.I. = 1 mrem/hr



RADIOACTIVE YELLOW III LABEL

*200 mrem/hr maximum on surface of package

*Maximum T.I. = 10 mrem/hr

2. Placards: Placards are required on all motor transport vehicles that transport Radioactive-Yellow III labeled packages, on exclusive use vehicles which may have packages without labels, or on vehicles carrying surface contaminated objects. Motor transport vehicles must have the appropriate placards applied to each end and to each side of the trailer. Standard size of the placards is approximately 10 ³/₄ x 10 ³/₄ inches.



FIGURE 4.
TYPICAL RADIOACTIVE WARNING PLACARD

3. Shipping Papers: Each motor transport vehicle must have a completed manifest kept in the driver's compartment. A description of all radioactive packages in the trailer will be available in accordance with Title 49, Subpart C of the Code of Federal Regulations.

FIGURE 5. Sample Shipping Papers

UN300 190 Baldwin Ave., Jersey City, NJ 07306 - (800) 631-3098 - (201) 795-5400

Form No. 35-553H

STRAIGHT BILL OF LADING—SHORT FORM ORIGINAL — NOT NEGOTIABLE

Carrier ABC Freight (913) 222-2222 Shipper's No. 113
Agent's No. 2013

At 10:50 a.m. 18 March 1997 From XYZ Materials Lab (913) 333-3333 TRUCK ☐
FREIGHT ☒

RECEIVED, subject to the classifications and tariffs in effect on the date of the issue of this Bill of Lading, the property described below in apparent good order, except as noted (contents and condition of contents of packages unknown), marked, consigned, and destined as indicated below which said carrier (the word carrier being understood throughout this contract as meaning any person or corporation in possession of the property under the contract) agrees to carry to its usual place of delivery at said destination, if on its route, otherwise to deliver to another carrier on the route to said destination. It is mutually agreed as to each carrier of all or any of, said property over all or any portion of said route to destination and as to each party at any time interested in all or any said property, that every service to be performed hereunder shall be subject to all the bill of lading terms and conditions in the governing classification on the date of shipment.

Shipper hereby certifies that he is familiar with all the bill of lading terms and conditions in the governing classification and the said terms and conditions are hereby agreed to by the shipper and accepted for himself and his assigns.

Consigned to Mythical Regional Hospital, 123 South Street (913) 444-4444
Destination Topeka, KS 66620 State of KS County of USA
Route I-70

Delivering Carrier ABC Freight Vehicle or Car Initial 17 No. NA

No. Packages	DESCRIPTION AND CLASSIFICATION Proper Shipping Name, Class and Identification Number per 172.101, 172.202, 172.203	UN# or NA#	*Weight (Sub. to Cor.)	Class or Rate	*Check Column
1	Radioactive Material, N.O.S., 7, I-131 Inorganic Salt/liquid, 3.7 GBq (100 mCi) US DOT 7A Type A Radioactive Yellow II, TI=0.3	2982	70		
1	Radioactive Material, N.O.S., 7, Tc-99m Liquid, 3.7 GBq (100 mCi) US DOT 7A, Type A Radioactive Yellow II, TI=0.15	2982	40		
1	Radioactive Material, N.O.S., 7, Tl-201 Liquid, 9.2 GBq (250 mCi) US DOT 7A, Type A Radioactive Yellow II, TI=0.3	2982	40		

Emergency Contact (913) 333-4444

THIS SHIPMENT IS CORRECTLY DESCRIBED. ☒ The fibre boxes used for this shipment conform to the specifications set forth in the box maker's certificate thereon, and all other requirements of the Consolidated Freight Classification.

CORRECT WEIGHT IS 150 LBS. ☒ Shipper's imprint in lieu of stamp, not a part of Bill of Lading approved by the Interstate Commerce Commission.

*If the shipment moves between two ports by a carrier by water, the law requires that the bill of lading shall state whether it is carrier's or shipper's weight.
NOTE — Where the rate is dependent on value, shippers are required to state specifically in writing the agreed or declared value of the property.
The agreed or declared value of the property is hereby specifically stated by the shipper to be not exceeding _____ Per _____

Permanent post-office address of shipper: _____

Shipper, Per _____

Agent, Per _____

Subject to Section 7 of conditions of applicable bill of lading, if this shipment is to be delivered to the consignee without recourse on the consignor, the consignor shall sign the following statement: The carrier shall not make delivery of this shipment without payment of freight and all other lawful charges.

Per: _____
(Signature of Consignor)

If charges are to be prepaid, write or stamp here, "To Be Prepaid."
To Be Prepaid _____

Received \$ _____
to apply in prepayment of the charges on the property described hereon.

Agent or Cashier, _____

Per: _____
(The signature here acknowledges only the amount prepaid.)

Charges Advanced \$ _____

C.O.D. SHIPMENT
Prepaid ☐
Collect ☐ \$ _____
Collection Fee _____
Total Charges _____

This is to certify that the above-named materials are properly classified, described, packaged, marked and labeled and are in proper condition for transportation according to the applicable regulations of the Department of Transportation.

NOTE: Transportation regulations are contained in Title 49, Parts 172 and 173 of the Code of Federal Regulations (CFR).

4. Caution Signs: Wherever radioactive materials or radiation-generating devices such as x-ray machines are used, their presence will usually be indicated by posted signs on entry doors, storage vaults, cabinets, or containers. In general,
- a. "Radiation Area" signs are used to identify areas which are accessible to individuals in which there exists radiation at such levels that at 30 centimeters from the source or any surface that the radiation penetrates, an individual could receive a dose equivalent in excess of five (5) millirems.
 - b. "High Radiation Area" signs are used to identify any area (not including rooms or areas in which diagnostic x-ray systems are used for healing arts purposes) which is accessible to individuals in which there exists radiation at such levels that a major portion of the body could receive, in any one hour, at 30 centimeters from the source or any surface that the radiation penetrates a dose to the whole body in excess of 100 millirems.
 - c. "Very High Radiation Area" signs are used to identify an area, accessible to individuals, in which radiation levels could result in an individual receiving an absorbed dose in excess of five Gy (500 rad) in one hour at one meter from a source of radiation or from any surface that the radiation penetrates.

These definitions are taken from the State of Kansas Radiation Protection Regulations, Revised 1996, Page 1-2.

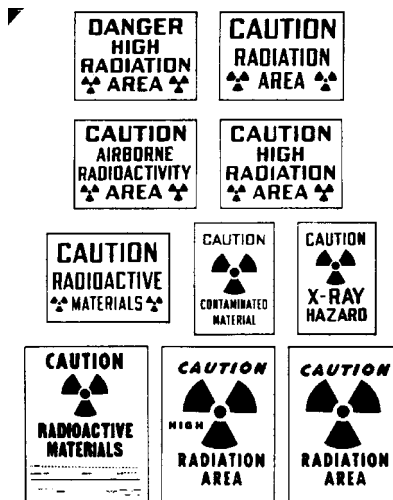


FIGURE 6.
TYPICAL SIGNS OR LABELS INDICATING THE PRESENCE
OF RADIATION OR RADIOACTIVE MATERIALS

APPENDIX C

Hospitals with Nuclear Medicine Programs

The following is a partial list of hospitals in Kansas which routinely use radioactive materials. These hospitals have personnel and equipment which could be useful in situations involving radiological emergencies:

<u>Arkansas City, Kansas</u> SC KS Regional Medical Ctr 1st & Birch Street (316) 442-2500	<u>Hutchison, Kansas</u> Hutchison Hospital Corp. 1701 East 3rd (316) 662-1212	<u>Pittsburg, Kansas</u> Mt. Carmel Medical Center Centennial & Rouse Streets (316) 231-6100
<u>Burlington, Kansas</u> Coffey County Hospital 4th and Garrettson (316) 364-2122	<u>Independence, Kansas</u> Mercy Hospital of Kansas 800 West Myrtle Street (316) 331-2200	<u>Pratt, Kansas</u> Pratt Regional Medical Center 200 Commodore (316) 672-6476
<u>Chanute, Kansas</u> Neosho Memorial Hospital 629 South Plummer (316) 431-4000	<u>Kansas City, Kansas</u> University of KS Medical Ctr 39th & Rainbow (913) 588-6126	<u>Salina, Kansas</u> Salina Regional Health Center 139 North Penn (785) 827-5591
<u>Concordia, Kansas</u> Cloud County Health Center 1100 Highland Drive (785) 243-1234	<u>Kansas City, Kansas</u> Providence Medical Center 8929 Parallel Parkway (913) 596-4000	<u>Topeka, Kansas</u> Stormont-Vail Regional Medical Ctr 1500 W. 10th (785) 354-6111
<u>Dodge City, Kansas</u> Columbia Western Plains Medical Complex 3001 Avenue A (316) 225-9050	<u>Lawrence, Kansas</u> Lawrence Memorial Hospital 325 Maine (785) 843-3680	<u>Topeka, Kansas</u> St. Francis Medical Center 1700 S.W. 7th (785) 295-8000
<u>Emporia, Kansas</u> Newman Memorial Co Hospital 1201 W. 12th Street (316) 343-6800	<u>Liberal, Kansas</u> Southwest Medical Center West 15th at Pershing St. (316) 624-1651	<u>Wichita, Kansas</u> Via Christi Regional Medical Ctr 929 North St. Francis (316) 268-5000
<u>Great Bend, Kansas</u> Central Kansas Medical Ctr 3515 Broadway (316) 689-5035	<u>Manhattan, Kansas</u> Mercy Health Center of Manhattan Sunset and Claflin (785) 776-3300	<u>Wichita, Kansas</u> Wesley Medical Center 550 N. Hillside (316) 688-2468
<u>Hays, Kansas</u> Hays Medical Center 201 East 7th, Hadley Campus (785) 628-8251	<u>Overland Park, Kansas</u> Overland Park Regional Medical Ctr 10500 Quivira, P.O. 5959 (913) 541-5000	

APPENDIX D

Table of Nuclides

Listed in the table below are a selected number of radionuclides that are commonly transported and used by medical, industrial, and government organizations. The first column shows the name of the chemical element and the symbol for the radionuclide. The radionuclides are presented in alphabetical order by chemical name. The half-lives are shown in their natural units, e.g., days (D), minutes (M), years (Y), etc. (Exponential numbers are listed in the form X.YEZ, which translates to $X.Y \times 10^Z$.) The radiations emitted are identified as alpha (α), beta (β) (includes monoenergetic electrons), and gamma (γ) (which includes x-rays). The A_1 and A_2 values (limits on package content) are from the U.S. Department of Transportation Regulation 49 CFR 173.435, revised October 1, 1995, and are listed in both Curies (Ci) and terabecquerels (Tbq).

Table 1.

Nuclide	Half-Life	Radiation	--A ₁ -- (Ci)	--A ₂ -- (Ci)	--A ₁ -- (Tbq)	--A ₂ -- (Tbq)
<i>Americium</i>						
Am-241	432.2 Y	α β γ	54.1	5.41E-3	2	2E-4
<i>Antimony</i>						
Sb-125	2.77 Y	β γ	54.1	24.3	2	0.9
<i>Argon</i>						
Ar-41	1.827 H	β γ	16.2	16.2	0.6	0.6
<i>Barium</i>						
Ba-133	10.74 Y	β γ	81.1	81.1	3	3
<i>Cadmium</i>						
Cd-109	464 D	β γ	1080	27.0	40	1
<i>Calcium</i>						
Ca-45	163 D	β γ	1080	24.3	40	40
<i>Californium</i> [†]						
Cf-252	2.638 Y	α β γ	2.70	2.7E-2	0.1	1E-3
<i>Carbon</i>						
C-14	5730 Y	β	1080	54.1	40	2
<i>Cesium</i>						
Cs-137	30.0 Y	β γ	54.1	13.5	2	0.5
<i>Chromium</i>						
Cr-51	27.70 D	β γ	811	811	30	30
<i>Cobalt</i>						
Co-57	270.9 D	β γ	216	216	8	8
Co-60	5.271 Y	β γ	10.8	10.8	0.4	0.4
<i>Copper</i>						
Cu-64	12.701 H	β γ	135	24.3	5	0.9
<i>Curium</i>						
Cm-244	18.11 Y	α β γ	1080	1.08E-2	4	4E-4
<i>Gadolinium</i>						
Gd-153	242 D	β γ	270	135	10	5
<i>Gallium</i>						
Ga-67	78.26 H	β γ	162	162	6	6

[†] Also a neutron source

Table 1, Continued

Nuclide	Half-Life	Radiation	--A ₁ -- (Ci)	--A ₂ -- (Ci)	--A ₁ -- (TBq)	--A ₂ -- (TBq)
<i>Hydrogen</i>						
H-3 (tritium)	12.35 Y	β	1080	1080	40	40
<i>Indium</i>						
In-111	2.83 D	β γ	54.1	54.1	2	2
<i>Iodine</i>						
I-123	13.2 H	β γ	162	162	6	6
I-125	60.14 D	β γ	541	54.1	20	2
I-131	8.04 D	β γ	81.1	13.5	3	0.5
<i>Iridium</i>						
Ir-192	74.02 D	β γ	27.0	13.5	1	0.5
<i>Iron</i>						
Fe-55	2.7 Y	β γ	1080	1080	40	40
Fe-59	44.529 D	β γ	21.6	21.6	0.8	0.8
<i>Krypton</i>						
Kr-85	10.72 Y	β γ	541	270	20	10
<i>Lead</i>						
Pb-203	52.05 H	β γ	81.1	81.1	3	3
Pb-210	22.3 Y	β γ	16.2	0.243	0.6	9E-3
<i>Manganese</i>						
Mn-54	213.5 D	β γ	27.0	27.0	1	1
Mn-56	2.5785 H	β γ	5.41	5.41	0.2	0.2
<i>Mercury</i>						
Hg-203	46.60 D	β γ	108	24.3	4	0.9
<i>Molybdenum</i>						
Mo-99	66.0 H	β γ	16.2	13.5 ^{††}	0.6	0.5
<i>Nickel</i>						
Ni-63	96 Y	β	1080	811	40	30
<i>Phosphorus</i>						
P-32	14.29 D	β	8.11	8.11	0.3	0.3
P-33	25.4 D	β	1080	24.3	40	0.9
<i>Plutonium</i>						
Pu-238	87.74 Y	α β γ	54.1	5.4E-3	2	2E-4
Pu-239	24065 Y	α β γ	54.1	5.41E-3	2	2E-4
Pu-241	14.4 Y	α β γ	1080	0.270	40	1E-2
<i>Polonium</i>						
Po-210	138.38 D	α β γ	1080	0.541	40	2E-2
<i>Potassium</i>						
K-43	22.6 H	β γ	27.0	13.5	1.0	0.5
<i>Radium</i>						
Ra-226	1600 Y	α β γ	8.11	0.541	0.3	2E-2
Ra-228	5.75 Y	α β γ	16.2	1.08	0.6	4E-2
<i>Radon</i>						
Rn-222	3.8235 D	α β γ	5.41	0.108	0.2	4E3
<i>Ruthenium</i>						
Ru-103	39.28 D	β γ	54.1	24.3	2	0.9
<i>Selenium</i>						
Se-75	119.8 D	β γ	81.1	81.1	3	3
<i>Sodium</i>						
Na-22	2.602 Y	β γ	13.5	13.5	0.5	0.5
Na-24	15.00 H	β γ	5.41	5.41	0.2	0.2

^{††} 20 Ci Mo-99 for domestic use

Table 1, Continued

Nuclide	Half-Life	Radiation	--A ₁ -- (Ci)	--A ₂ -- (Ci)	--A ₁ -- (TBq)	--A ₂ -- (TBq)
<i>Strontium</i>						
Sr-89	50.5 D	β γ	16.2	13.5	0.6	0.5
Sr-90	29.12 Y	β	5.41	2.70	0.2	0.1
<i>Sulfur</i>						
S-35	87.44 D	β	1080	54.1	40	2
<i>Technetium</i>						
Tc-99	2.13E5 Y	β	1080	24.3	40	0.9
Tc-99m	6.02 H	β γ	216	216	8	8
<i>Thallium</i>						
Tl-201	3.044 D	β γ	270	270	10	10
<i>Thorium</i>						
Th-230	7.7E4 Y	α β γ	54.1	5.41E-3	2	2E-4
Th-232	1.405E10 Y	α β γ	Unlimited	Unlimited	Unlimited	Unlimited
<i>Tungsten</i>						
W-181	121.2 D	β γ	811	811	30	30
<i>Uranium</i>						
U-234	2.445E5 Y	α β γ	270	2.7E-2	10	1E-3
U-235	703.8E6 Y	α β γ	Unlimited	Unlimited	Unlimited	Unlimited
<i>Xenon</i>						
Xe-133	5.245 D	β γ	541	541	20	20
<i>Zinc</i>						
Zn-65	243.9 D	β γ	54.1	54.1	2	2

APPENDIX E

Conversion Charts for SI Units

RADIATION DOSE: The working SI unit is the sievert (Sv) (dose equivalent)

ACTIVITY: The SI unit is the Becquerel (Bq).
 $1 \text{ Bq} = 1 \text{ disintegration per second} = 2.7\text{E}10^{-11} \text{ Ci}$

<u>DOSE</u>		<u>AMOUNT</u>	
rem	sievert	Curie	Becquerel
0.1 mrem	1 μSv	1 pCi	37 mBq
1 mrem	10 μSv	27 pCi	1 Bq
10 mrem	100 μSv (0.1 mSv)	1 nCi	37 Bq
100 mrem	1 mSv	27 nCi	1 kBq
500 mrem	5 mSv	1 μCi	37 kBq
1 rem	10 mSv	27 μCi	1 MBq
5 rem	50 mSv	1 mCi	37 MBq
10 rem	100 mSv	27 mCi	1 GBq
25 rem	250 mSv	1 Ci	37 GBq
50 rem	500 mSv	27 Ci	1 TBq
100 rem	1 Sv	1 kCi	37 TBq
		27 kCi	1 PBq
		1 MCi	37 Pbq

Conversion between grays (absorbed dose) and rads is the same as between sieverts and rems, i.e.,

$$1 \text{ gray (Gy)} = 100 \text{ rads} \approx 100 \text{ roentgens}$$

Common Prefixes for SI Units:

E	exa	10^{18}
P	peta	10^{15}
T	tera	10^{12}
M	mega	10^6
k	kilo	10^3
c	centi	10^{-2}
m	milli	10^{-3}
μ	micro	10^{-6}
n	nano	10^{-9}
p	pico	10^{-12}